# PATENT SPECIFICATION

*Inventor*: WILLIAM THOMPSON

DRAWINGS ATTACHED

**886,247**

*Date of filing Complete Specification July 28, 1959.*

*Application Date May 2, 1958.* *No. 14014/58.*

*Complete Specification Published Jan. 3, 1962.*

Index at acceptance:—Class 37, A19(H:L2:M).

International Classification:—G01n.

COMPLETE SPECIFICATION

## Improvements in or relating to Structures to Facilitate Non-Destructive Testing Thereof

I, MINISTER OF AVIATION, (formerly Minister of Supply), London, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

In the non-destructive testing of certain metal structures, for example aircraft, it is not possible, or is at least very difficult, to obtain access to various parts of the structure, to apply thereto the testing means for ascertaining, for instance, whether any cracks or certain other physical changes have taken place in the structure, and, in some cases, this necessitates the dismantling of some of its parts.

According to the invention, during the manufacture of the structure, there is permanently incorporated, each at a different part of this, a washer or gasket having a built-in coil, the coil of each of which washers or gaskets is permanently wired to a location which will be easy of access, to enable the impedance of the coil to be periodically measured at the said location, for the purpose of ascertaining whether any cracking or other physical change has been produced in the part of the structure where this coil is incorporated.

An initial measurement, based on the impedance of each coil to alternating current, is made at the location to which the coil is wired, and periodic measurements are made thereat and compared with the initial measurement. Thus, assuming the periodic check-up measurements are made at the same temperature as the initial measurement, should there be any substantial difference between a subsequent measurement and the initial measurement, this would indicate the presence of a crack at the point of the structure where the coil is incorporated. This would be due to the fact that any such crack would vary the eddy current or currents induced by the coil in the adjacent part of the structure with the coil connected, through the permanent wiring leading to the said location, into one arm of an alternating current bridge, and this variation in eddy current would effect a sensible change in the impedance of the coil.

The impedance of selected pairs of the coils may be initially measured (when both coils are at ambient temperature) at the said location or locations, by including the coils of each pair one in each side of an alternating current bridge, so that the impedance of these coils (whilst they are again both at ambient temperature) can subsequently be measured in the same manner. By measuring the impedance of the pairs of coils in this manner, any differences between ambient temperatures at which the initial and subsequent periodic measurements are made will cancel out between the opposite sides of the bridge.

In the case of an aircraft component, cracking would normally occur only as a result of fatigue damage, intercrystalline or severe surface corrosion, or, of course, fracture of the component due to overstressing in service.

In many cases the leads from the respective coils may be connected to sockets carried upon a single panel disposed at the aforesaid accessible position and having numbers or other indications to denote the locations of the said coils upon or within the structure. Any of the proprietary instruments which incorporate a suitable impedance bridge may be used to check the impedance values at regular intervals of time throughout the life of an aircraft or other structure.

[*Price* 4*s.* 6*d.*]

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Instead of using a pair of leads for each coil, one end of the coil may be connected to the metal structure so that this will act as one conductor, in which case only one lead need be used for each coil.

The invention will now be described, by way of example, with reference to the accompanying drawings, of which:—

Figure 1 is a diagrammatic view showing a part of a structure having test coils and comprising two girder members bolted together;

Figure 2 is a circuit diagram of means for testing pairs of the coils shown in Figure 1.

The part of the structure shown in Figure 1 comprises a girder 1 and a girder 2 held together by bolts 3, beneath the heads of which bolts are disposed peripherally recessed washers 4 carrying coils 5, 6, 7, 8, 9, 10, 11 and 12, respectively.

The coil 5 is connected by leads $5^a$, $5^b$, respectively, to terminals 13, 14, of a terminal board 15 of insulating material which would be installed at a point of easy access upon or in relation to the structure. The coil 6 is connected by leads $6^a$, $6^b$ to terminals 16, 17, of the said terminal board. The remaining coils, 7 to 12, inclusive, would be connected in a similar manner to the respective pairs of terminals 18 and 19, 20 and 21, 22 and 23, 24 and 25, 26 and 27, 28 and 29, by conductors similar to the wires $5^a$, $5^b$ and $6^a$, $6^b$, but which further conductors have, for the sake of clearness, been omitted.

In Figure 2 is shown a form of portable measuring apparatus comprising a branch of a bridge having arms A.D. and C.D., and a pair of headphones or other detector, indicated generally by 30, included in a central conductor extending from a point B to D. The arm C.D. of the bridge comprises a resistor 31, and the arm A.D. of the bridge comprises a variable resistor 32, the slider of which is indicated by 33.

Connecting the extremities A and C, respectively, of branch A, D, C, of the bridge to terminals 34, 35, are conductors 36, 37.

When the portable testing means is to be used, the terminals 34 and 35 can be connected to an audio-frequency generator (not shown).

The apparent impedance of the coils can be measured in pairs. Thus, dealing with the coils in the pairs already mentioned, and commencing with the coils 5 and 6, the terminals 14 and 17 of the terminal panel 15 would be connected together and to the point B of the testing means, and the terminals 13 and 16 would be connected respectively to the points A and C of the testing means, so that these two coils would constitute the second arm of the bridge. The audio-frequency generator would then be brought into operation and the slider 33 of the variable resistor moved until a minimum or no signal would be heard in the headphones and the final setting of the slider recorded. The remaining pairs of coils would be tested in the same manner as the coils 5 and 6 and the final setting of the slider recorded for each pair. These measurements constitute the initial measurements based on the apparent impedance of the coils, against which will be compared measurements each time the aforesaid periodic tests are made.

WHAT I CLAIM IS:—

1. A metal structure in which is permanently incorporated each at a different part thereof, during manufacture of the structure, a washer or gasket having a built-in coil, the coil of each of which washers or gaskets is permanently wired to a location which will be easy of access, to enable the impedance of the coil to be periodically measured at the said location, for the purpose of ascertaining whether any cracking or other physical change has been produced in the part of the structure where this coil is incorporated.

2. A metal structure with which are permanently incorporated, during its manufacture, coils which are permanently wired to a location which will be easy of access, substantially as described with reference to Figure 1 of the accompanying drawings.

R. G. CHANNEN,
Chartered Patent Agent,
Agent for the Applicant.

## PROVISIONAL SPECIFICATION

## Improvements in or relating to Structures to Facilitate Non-Destructive Testing Thereof

I, MINISTER OF SUPPLY, London, do hereby declare this invention to be described in the following statement:—

In the non-destructive testing of certain metal structures, for example, of aircraft, it is not possible, or is at least very difficult, to obtain access to various parts of the structure, to apply thereto the testing means for ascertaining, for instance, whether any cracks or certain other physical changes have taken place in the structure, and in some cases, this necessitates the dismantling of some of the parts of the structure.

According to the invention there is or are provided at the point or points of a metal structure at which periodic tests will have to be made, a coil or coils of wire which are electrically connected to a point or points which will be easy of access, in order that, when it is desired to make these tests, this

may be effected by passing an alternating current through the coil or each coil and measuring the apparent impedance of the coil and comparing this with such impedance when it was initially installed in the structure.

When it is desired to detect and measure the development of cracks, the coil or coils is or are preferably positioned so that any crack which it is possible may form will vary to a maximum degree the eddy current or currents induced by the coil and thereby effect a sensible change in the impedance of the coil. Providing the conditions of test remain sensibly the same, any alteration in the impedance of the test coil will indicate some definite change in the homogeneity or in the surface continuity of the metal in its immediate vicinity. In the case of an aircraft component, such a change would normally occur only as a result of fatigue damage, intercrystalline or severe surface corrosion, or, of course, fracture of the component due to overstressing in service.

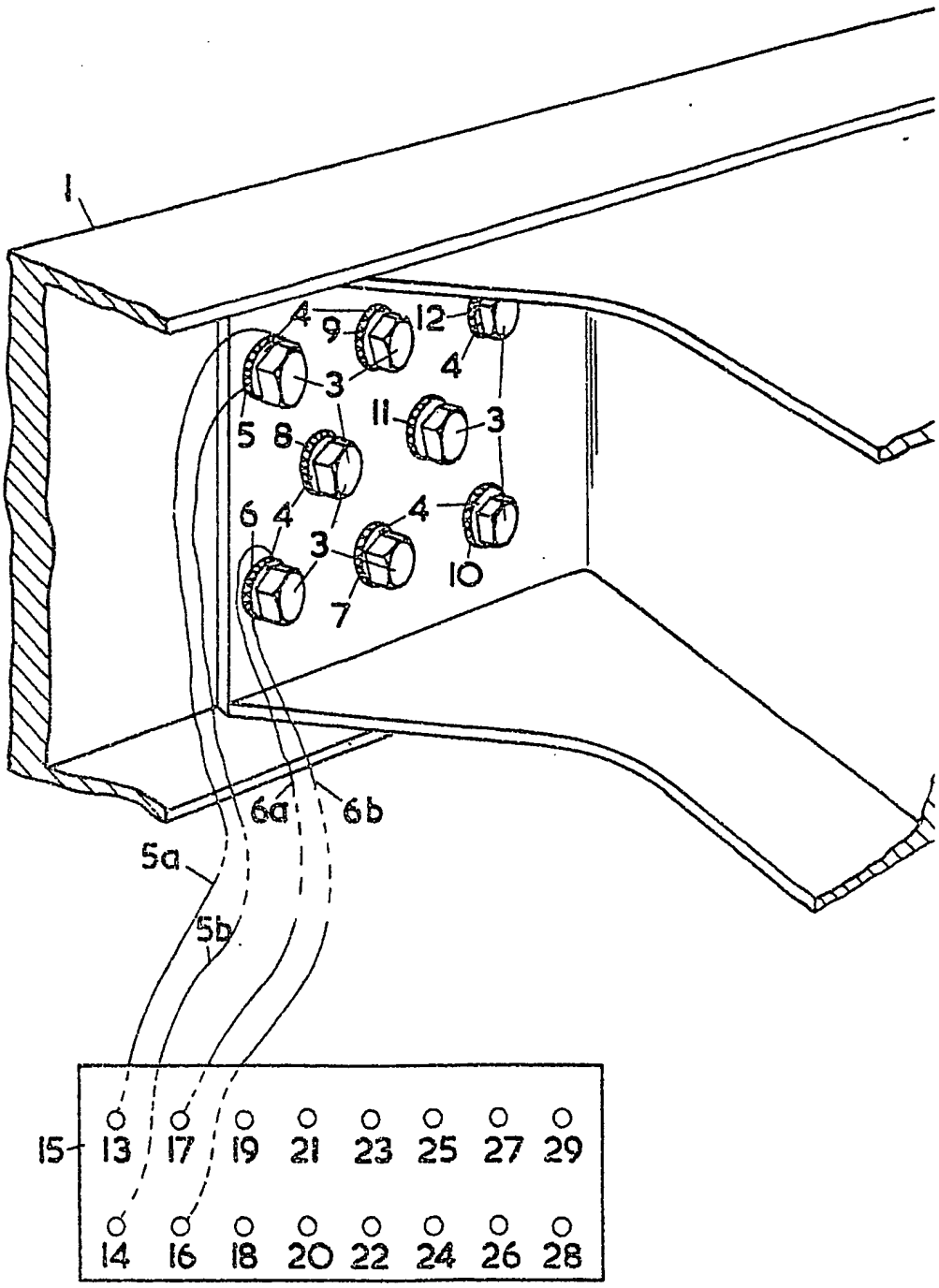
In accordance with the invention, therefore, a small test coil may be cemented to the surface of a part of a structural member which is to be periodically tested and will be difficult of access, and is permanently wired to a point which is readily accessible and from which it is possible to detect the aforesaid crack or other deterioration. In the case, for example, of two structural members which are bolted together, fatigue cracks frequently originate at the bolt holes. If the case is one in which the use of a resin bonded fibre or similar gasket between the two structural members can be tolerated, the invention may conveniently be carried into effect by building a coil into the gasket. This may be effected, for instance, after forming a suitable groove in or around the gasket.

In cases where a gasket cannot be used, any other suitable provision may be made, where necessary, for accommodating or positioning the coil which may, for example include the formation of a small annular enlargement at the appropriate end of the bolt hole or a recess around the bolt hole but separate therefrom or around any other area about or within the neighbourhood where the test is to be made. The coil or each coil may be connected by means of a printed circuit or insulated wires to the nearest accessible position within or adjacent the structure, as the case may be. In some cases it may be possible to apply printed circuit technique in the making and application of the coil or coils. It will, of course, in most cases, be necessary first to apply an insulating coating or layer to the part where the coil or each coil is to be printed and/or to the part over which the leads are to be printed.

In many cases the leads from the respective coils may be connected to sockets carried upon a single panel and having numbers or other indications to denote the locations of said coils upon or within the structure. Any of the proprietary instruments which incorporate a suitable impedance bridge may be used to check the impedance values at regular intervals of time throughout the life of an aircraft or other structure. Instead of using a pair of leads for each coil one end of the coil may be connected to the metal structure so that the latter will act as one conductor, in which case only one lead need be used for each coil.

R. G. CHANNEN,
Chartered Patent Agent,
Agent for the Applicant.

Leamington Spa: Printed for Her Majesty's Stationery Office, by the Courier Press.—1962.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.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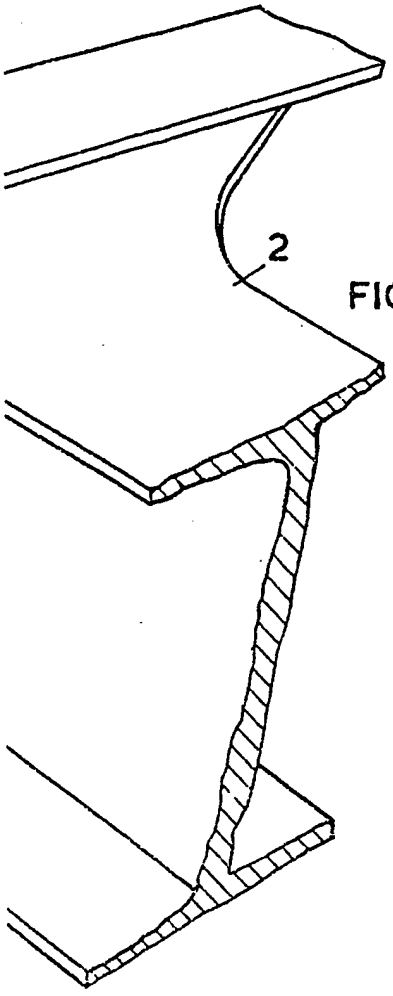


FIG. 1.

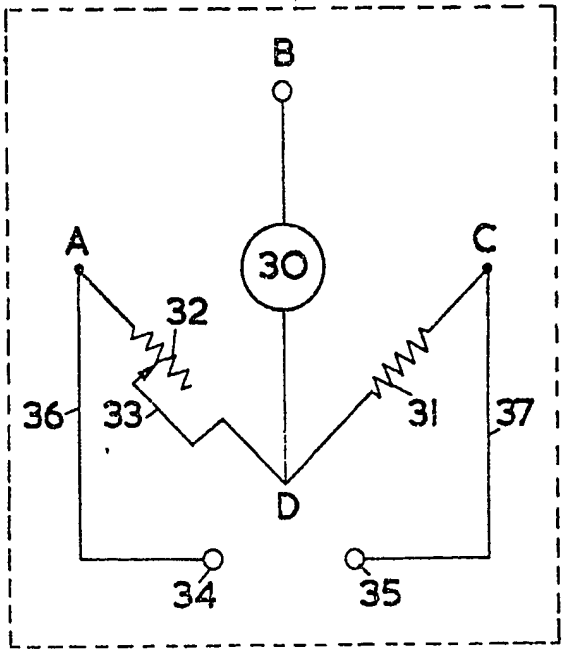


FIG. 2.

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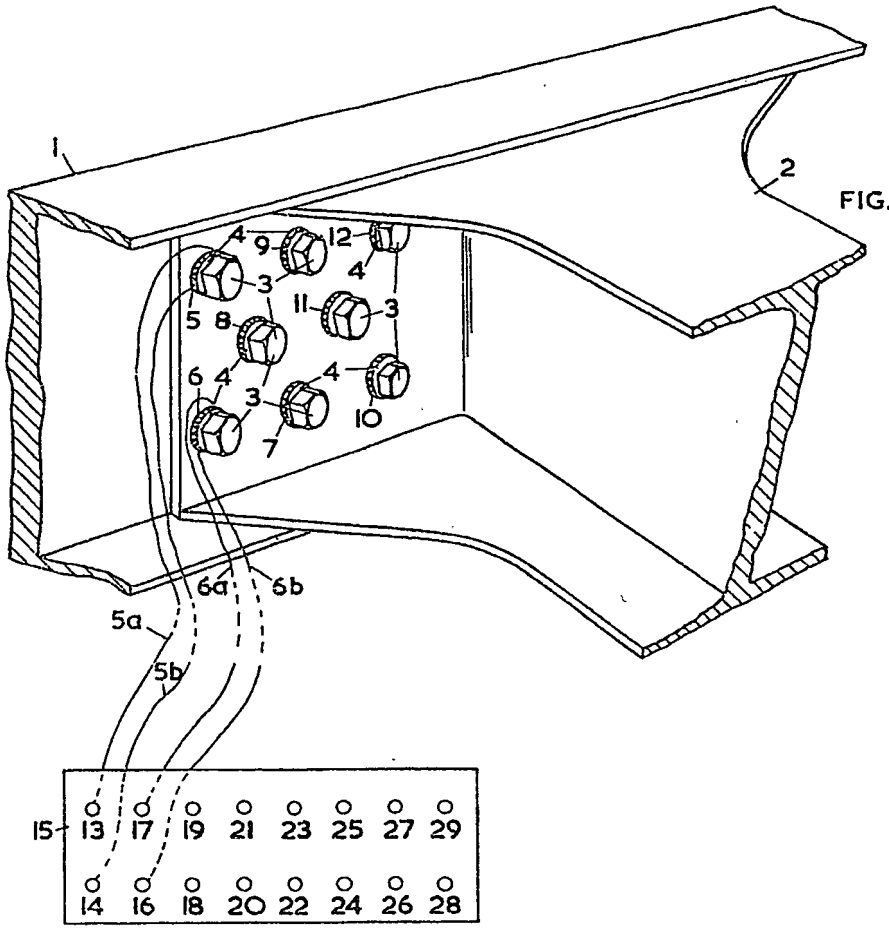


FIG. 1.

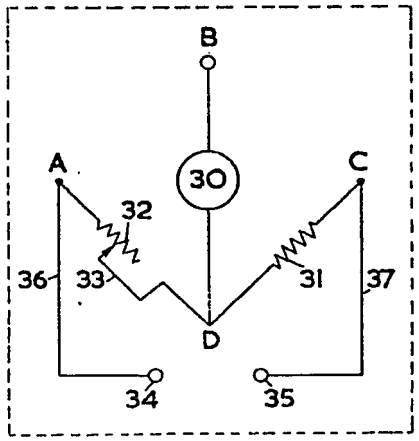


FIG. 2.